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DARLINGTON NGS 'A' - UNIT 2
LOW PRESSURE SERVICE WATER PUMPSETS
VIBRATION ACCEPTANCE TESTS

Report No 87-151-K

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ABSTRACT

As part of the Darlington NGS 'A' commissioning program, vibration acceptance tests were carried out on the Unit 2 Low Pressure Service Water Pumpset P1 (2-7210-P1) and Pumpset P3 (2-7210-P3). These tests indicated that the vibration levels and the dynamic characteristics are acceptable.

job	file	date	report no.
27-220-552	825.4	August 7, 1987	87-151-K

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EXECUTIVE SUMMARY

DARLINGTON NGS 'A' UNIT 2
LOW PRESSURE SERVICE WATER PUMPSETS
VIBRATION ACCEPTANCE TESTS

F. Perricone, N.A. Jagan and W.D. Morgan
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As part of the Darlington NGS 'A' commissioning program, vibration acceptance tests were carried out on the Unit 2 Low Pressure Service Water Pumpset P1 (2-7210-P1) and Pumpset P3 (2-7210-P3).

Overall vibration levels measured on the motors did not exceed 107 μm p-p which is below the maximum allowable vibration level specified in the Darlington NGS 'A' tendering documents, and are therefore considered acceptable. The motor dynamic characteristics determined by impact testing are also considered acceptable.

Vibration and dynamic characteristics data are presented in the report to provide a baseline to assist in future pumpset condition monitoring and assessment.

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27-220-552	825.4	August 7, 1987	87-151-K

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TO: Mr. S. Suurmann
Maintenance Superintendent
Darlington NGS 'A'

DARLINGTON NGS 'A' UNIT 2
LOW PRESSURE SERVICE WATER PUMPSETS
VIBRATION ACCEPTANCE TESTS

1.0 INTRODUCTION

Vibration acceptance tests were carried out on two Low Pressure Service Water Pumpsets - Unit 2 Pumpset #1 (2-7210-P1) and Unit 2 Pumpset #3 (2-7210-P3), as part of the commissioning program.

The objectives of the tests were to:

1. Evaluate the acceptability of pumpset vibration and dynamic characteristics with respect to specifications and/or industry standards.

2. Obtain baseline vibration data for use in future pumpset monitoring.

3. Make recommendations for corrective action if required.

Each vertical pumpset consists of a single stage Ingersoll-Rand Pump with a rated capacity of 2110 L/s (33444 GPM) and a head of 48.2 m (158 ft), as well as a Reliance Induction Motor rated at 1300 kW at 713 RPM.

2.0 TEST METHOD, INSTRUMENTATION AND MEASUREMENTS

2.1 Test Method

The general pumpset arrangement, measurement locations and directions, as well as the identification used for the report, are shown in Figure 1. Vibration measurements were taken at the top and bottom of the motor, and at the pump seal flange (within the motor pedestal) in both the E-W and N-S directions during pumpset operation. The E-W direction is referred to as the "soft direction" (ie. perpendicular to the discharge line), and the N-S direction referred to as the "hard direction" (ie. parallel to the discharge line).

Since the LPSW pumpsets are required to operate with acceptable vibration levels through a range of flow rates, vibration measurements were taken at two service conditions. They were:

Test	Pump Operating Condition	
	Discharge Pressure kPa	Flow Rate L/s
1	420	2400
2	450	2250

The flow rates are estimated using the measured pump discharge pressures and the pump curve supplied by the manufacturer (Figure 2).

2.2 Instrumentation

The instrumentation setup is shown in Figure 3 and is also discussed in Section 2.3.

2.3 Measurements

2.3.1 Overall Vibration Levels

The overall velocity and displacement levels were determined from accelerometer (Bruel & Kjaer Model 4368) signals which were integrated to velocity and then analyzed with a Bently Nevada Digital Vector Filter (DVF 2). The DVF 2 digital vector filter is a peak reading instrument.

2.3.2 Velocity Spectra

Velocity spectra were generated by analyzing the accelerometer signals (integrated once) with an Ono Sokki CF 940 dual channel Fast Fourier Transform (FFT) analyzer. Hard copies of the spectra were obtained with a digital plotter (Hewlett-Packard 7470A).

Each velocity spectrum shown in this report is the average of sixteen instantaneous spectra.

2.3.3 Impact Spectra

Motor structural natural frequencies in both the E-W and N-S directions were determined by impact testing. With the pumpsets not running, the motors were excited throughout a range of frequencies (5-200 Hz) with a hammer having an elastomeric tip and instrumented with a force transducer. The input force (hammer) and the motor response (accelerometer signal) signals were fed simultaneously into the dual channel FFT analyzer which calculated the input and response spectra as well as the inertance transfer function. The validity of the transfer function was checked by the coherence of the input and response signals. The ambient noise was reduced by averaging the results of eight impacts.

Impact tests were performed at the top of the motors.

3.0 RESULTS AND DISCUSSION

3.1 Overall Vibration Levels

The overall vibration velocity and displacement levels measured on Pumpsets P1 and P3, for the two service conditions, are summarized in Table 1 and Table 2. According to the Darlington NGS 'A' Tendering Document NK-38-TH-72102-01, the maximum peak-to-peak displacement measured at the top of the motor should not exceed 125 μm p-p at 600 RPM , or 62 μm p-p at 1200 RPM.

The results of the commissioning tests show the following:

1. For Pumpset #1, the maximum overall casing displacement occurs at the top of the motor in the E-W (soft) direction for both service conditions. At 420 kPa (2400 L/s), the displacement level is 85 μm p-p and at 450 kPa (2250 L/s), it is 107 μm p-p.

2. For Pumpset #3, the maximum overall casing displacement occurs at the top of the motor in the E-W (soft) direction for both service conditions. At 420 kPa (2400 L/s), the displacement level is 48 μm p-p and at 450 kPa (2250 L/s), it is 97 μm p-p.

These vibration levels are considered acceptable.

3.2 Velocity Spectra

The main vibration frequencies and the corresponding velocity amplitudes, for the two service conditions are summarized in Tables 3, 4 and 5 for Pumpsets P1 and P3. The corresponding velocity spectra figure numbers are also shown in the tables. No velocity spectra were taken on Pumpset P1 at the service condition of 450 kPa (and 2250 L/s).

On both pumpsets, the 1 x RPM velocity vibration levels measured on the motor casing were relatively low indicating that the rotor balance is satisfactory.

Comparison of the spectral components at the two flow conditions for Pumpset P3 (Tables 4 and 5), indicates that at the rougher flow condition (450 kPa), the only significant increase in vibration occurs at 15.5-16 Hz (for example from 0.39 mm/s to 1.13 mm/s at the top of the motor). This increase is most likely due to flow-induced excitation of the motor structural natural frequencies of 15.5 Hz and 16 Hz (Section 3.3).

3.3 Pumpset Dynamic Characteristics

The impact spectra (inertance transfer functions) measured at the top of Pumpset P3 motor structure in the E-W and N-S directions are shown in Figures 23 and 24, respectively. These spectra show motor structural natural frequencies at 15.5 Hz (close to 1 x RPM) and 71.5 Hz (close to 6 x RPM - vane pass frequency) in the E-W (soft) direction, and at 16 Hz and 77.5 Hz in the N-S (hard) direction. These structural natural frequencies were also observed on the Pumpset P1 Motor.

The structural natural frequencies at 15.5 Hz and 16 Hz are sufficiently removed from the operating speed of 11.9 Hz and have little effect on the overall vibration levels. The structural natural frequency at 71.5 Hz appears to have little influence on the vibration levels as evidenced from the relatively low velocity component at 71.5 Hz in the velocity spectra obtained during pump operation (Tables 3, 4 and 5).

4.0 CONCLUSIONS

4.1 The measured overall vibration levels do not exceed the maximum allowable level specified in the Darlington NGS 'A' LPSW Pumpset tendering documents. Thus, the overall vibration levels are considered acceptable.

4.2 Motor structural natural frequencies are sufficiently removed from the operating speed. There is little excitation of a motor structural natural frequency close to the vane-pass frequency. Thus, the dynamic characteristics are considered acceptable.

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TABLE 1

OVERALL VELOCITY AND DISPLACEMENT LEVELS OBTAINED ON DARLINGTON NGS 'A'
UNIT #2 LOW PRESSURE SERVICE WATER PUMPSET #1

Measurement Location and Direction	Flow Condition (2400 L/s, 420 KPa)		Flow Condition (2250 L/s, 450 KPa)	
	Overall Velocity Level (mm/s 0-peak)	Overall Displacement Level (μm peak-peak)	Overall Velocity Level (mm/s 0-peak)	Overall Displacement Level (μm peak-peak)
TOP OF MOTOR CASING E-W	4.8 - 5.5	73 - 85	5.4 - 7.0	78 - 107
TOP OF MOTOR CASING N-S	4.2 - 5.1	58 - 75	4.5 - 6.2	62 - 92
BOTTOM OF MOTOR CASING E-W	2.5 - 2.7	35 - 40	-	-
BOTTOM OF MOTOR CASING N-S	2.5 - 2.7	31 - 37	-	-
PUMP SEAL FLANGE E-W	1.6 - 2.0	18 - 20	-	-
PUMP SEAL FLANGE N-S	0.8 - 0.9	8 - 10	-	-

TABLE 2

OVERALL VELOCITY AND DISPLACEMENT LEVELS OBTAINED ON DARLINGTON NGS 'A'
UNIT #2 LOW PRESSURE SERVICE WATER PUMPSET #3

Measurement Location and Direction	Flow Condition (2400 L/s, 420 KPa)		Flow Condition (2250 L/s, 450 KPa)	
	Overall Velocity Level (mm/s 0-peak)	Overall Displacement Level (μm peak-peak)	Overall Velocity Level (mm/s 0-peak)	Overall Displacement Level (μm peak-peak)
TOP OF MOTOR CASING E-W	3.8 - 4.8	35 - 48	5.0 - 6.2	50 - 97
TOP OF MOTOR CASING N-S	3.0 - 4.0	26 - 35	4.6 - 7.0	39 - 70
TOP OF MOTOR CASING AXIAL	-	-	3.0 - 4.3	15 - 22
BOTTOM OF MOTOR CASING E-W	2.6 - 3.0	22 - 30	3.1 - 4.3	25 - 52
BOTTOM OF MOTOR CASING N-S	2.7 - 3.1	15 - 25	3.7 - 4.3	23 - 39
PUMP SEAL FLANGE E-W	1.3 - 1.5	10 - 15	2.1 - 2.5	14 - 20
PUMP SEAL FLANGE N-S	0.6 - 0.8	4 - 7	1.9 - 3.4	7 - 11

TABLE 3
DARLINGTON NGS 'A' UNIT #2 LPSW PUMPSET P1
SUMMARY OF VIBRATION LEVELS AT SPECIFIC FREQUENCIES
SERVICE CONDITION : 420 KPa, 2400 L/S

Measurement Location and Direction	Vibration (mm/s pk) at					Fig. No.
	1xRPM (12 Hz)	15.5/ 16.0 Hz	24 Hz	71.5 Hz	120 Hz	
TOP OF MOTOR CASING E-W	2.49	0.45	0.56	0.72	0.83	4
TOP OF MOTOR CASING N-S	2.07	0.65	0.23	0.58	0.75	5
BOTTOM OF MOTOR CASING E-W	1.20	0.23	0.20	0.36	0.62	6
BOTTOM OF MOTOR CASING N-S	1.09	0.29	0.20	0.19	0.72	7
PUMP SEAL FLANGE E-W	0.54	0.09	-	0.77	0.20	8
PUMP SEAL FLANGE N-S	0.26	0.03	-	0.16	0.05	9

TABLE 4
DARLINGTON NGS 'A' UNIT #2 LPSW PUMPSET P3
SUMMARY OF VIBRATION LEVELS AT SPECIFIC FREQUENCIES
SERVICE CONDITION : 420 KPa, 2400 L/S

Measurement Location and Direction	Vibration (mm/s pk) at					Fig. No.
	1xRPM (12 Hz)	15.5/ 16.0 Hz	24 Hz	71.5 Hz	120 Hz	
TOP OF MOTOR CASING E-W	1.11	0.39	0.63	0.70	0.49	10
TOP OF MOTOR CASING N-S	0.72	0.38	0.53	0.50	0.68	11
BOTTOM OF MOTOR CASING E-W	0.63	0.35	0.31	0.50	0.96	12
BOTTOM OF MOTOR CASING N-S	0.44	0.27	0.36	0.39	0.89	13
PUMP SEAL FLANGE E-W	0.28	0.10	0.06	0.71	0.34	14
PUMP SEAL FLANGE N-S	0.13	0.03	0.03	0.08	0.10	15

TABLE 5
DARLINGTON NGS 'A' UNIT #2 LPSW PUMPSET P3
SUMMARY OF VIBRATION LEVELS AT SPECIFIC FREQUENCIES
SERVICE CONDITION : 450 KPa, 2250 L/S

Measurement Location and Direction	Vibration (mm/s pk) at					Fig. No.
	1xRPM (12 Hz)	15.5/ 16.0 Hz	24 Hz	71.5 Hz	120 Hz	
TOP OF MOTOR CASING E-W	1.20	1.13	0.86	0.62	0.49	16
TOP OF MOTOR CASING N-S	0.78	1.05	0.62	0.89	0.54	17
TOP OF MOTOR AXIAL	0.11	0.13	0.12	0.61	0.31	18
BOTTOM OF MOTOR CASING E-W	0.70	0.39	0.47	0.27	1.08	19
BOTTOM OF MOTOR CASING N-S	0.46	0.76	0.41	0.77	0.93	20
PUMP SEAL FLANGE E-W	0.31	0.23	-	0.72	0.31	21
PUMP SEAL FLANGE N-S	0.13	0.08	-	0.14	-	22

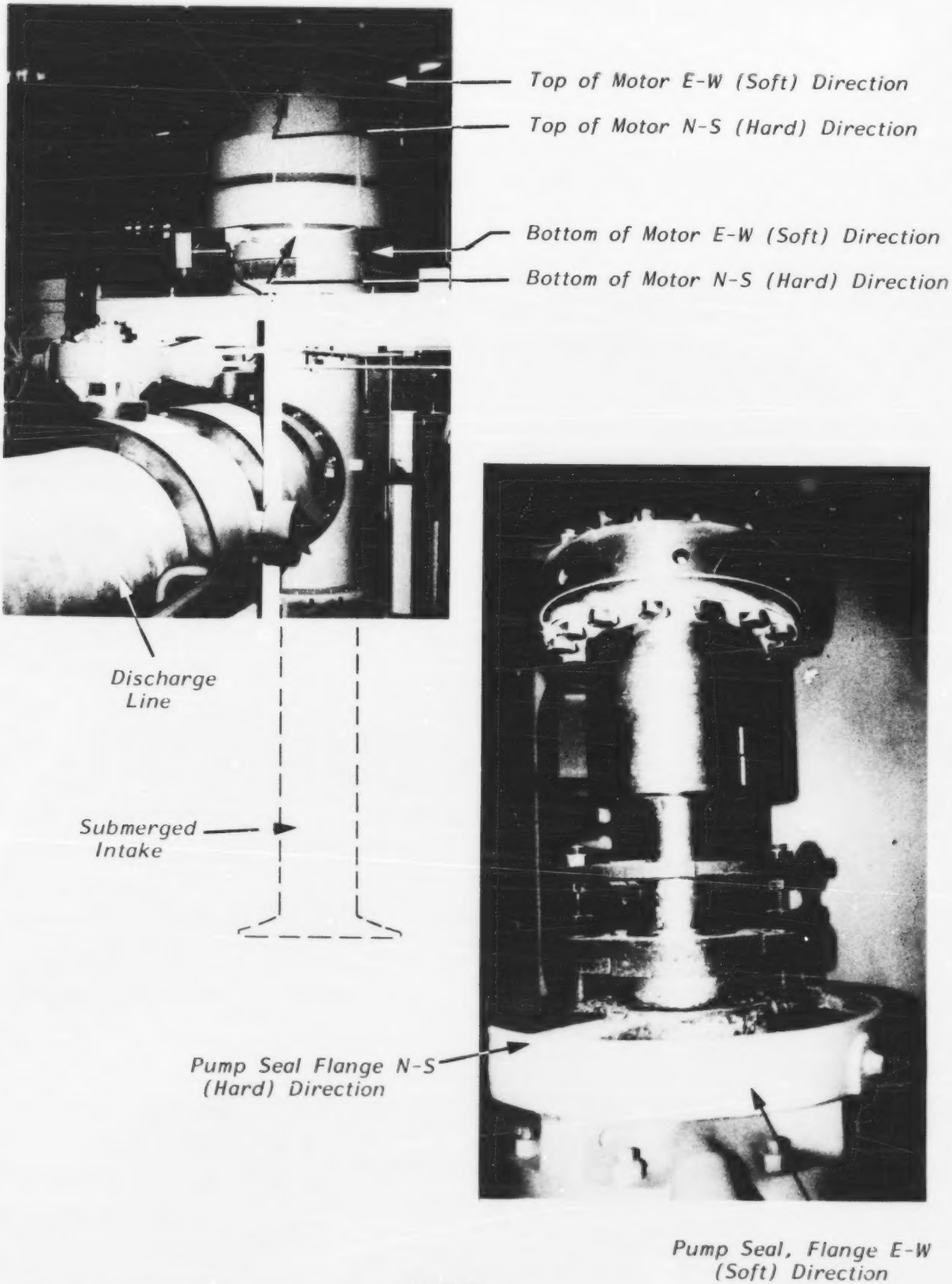
Top of Motor E-W (Soft) Direction
Top of Motor N-S (Hard) Direction
Bottom of Motor E-W (Soft) Direction
Bottom of Motor N-S (Hard) Direction
Discharge Line
Submerged Intake
Pump Seal Flange N-S (Hard) Direction
Pump Seal, Flange E-W (Soft) Direction

FIGURE 1

LPSW MEASUREMENT LOCATIONS AND DIRECTIONS

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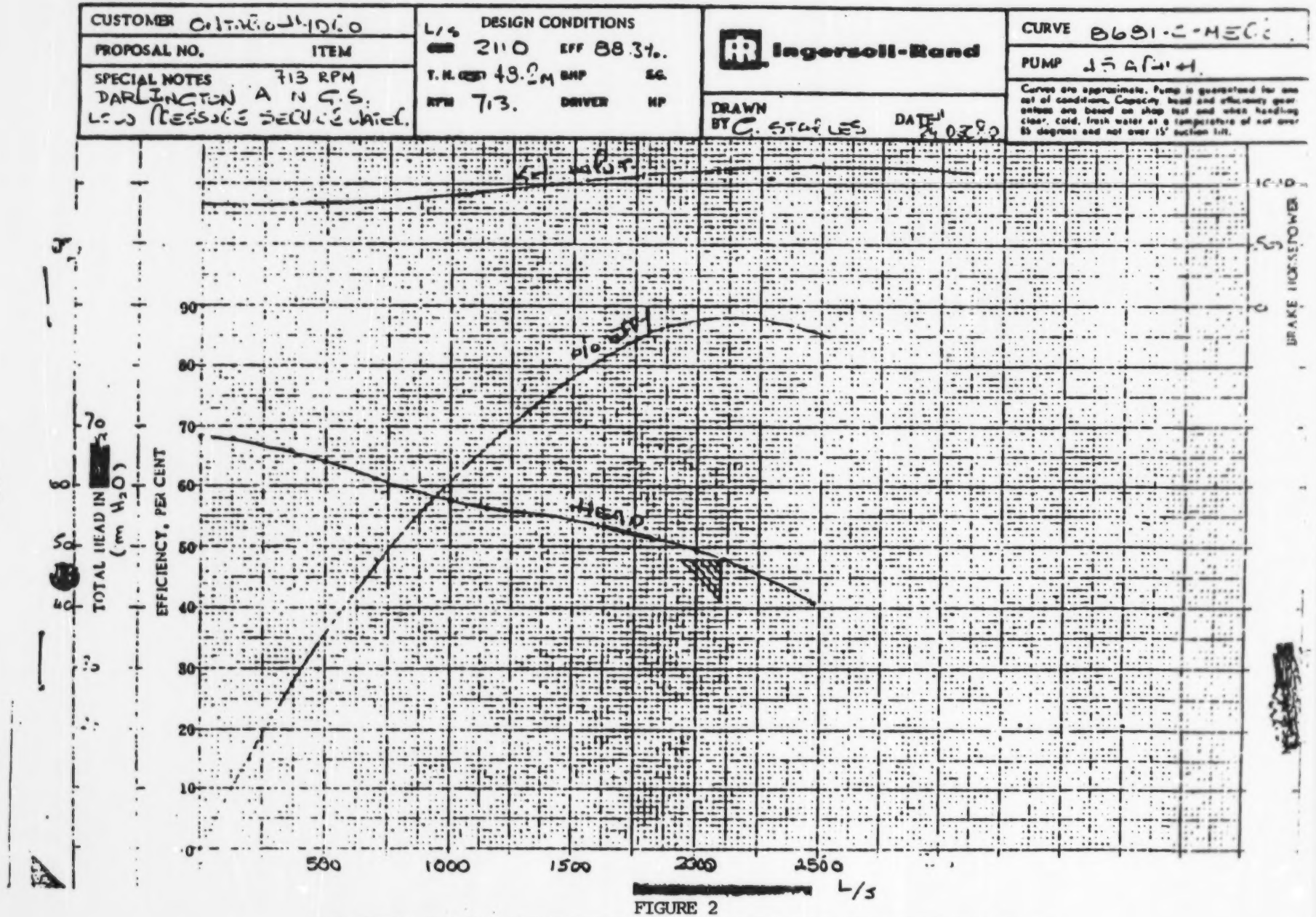
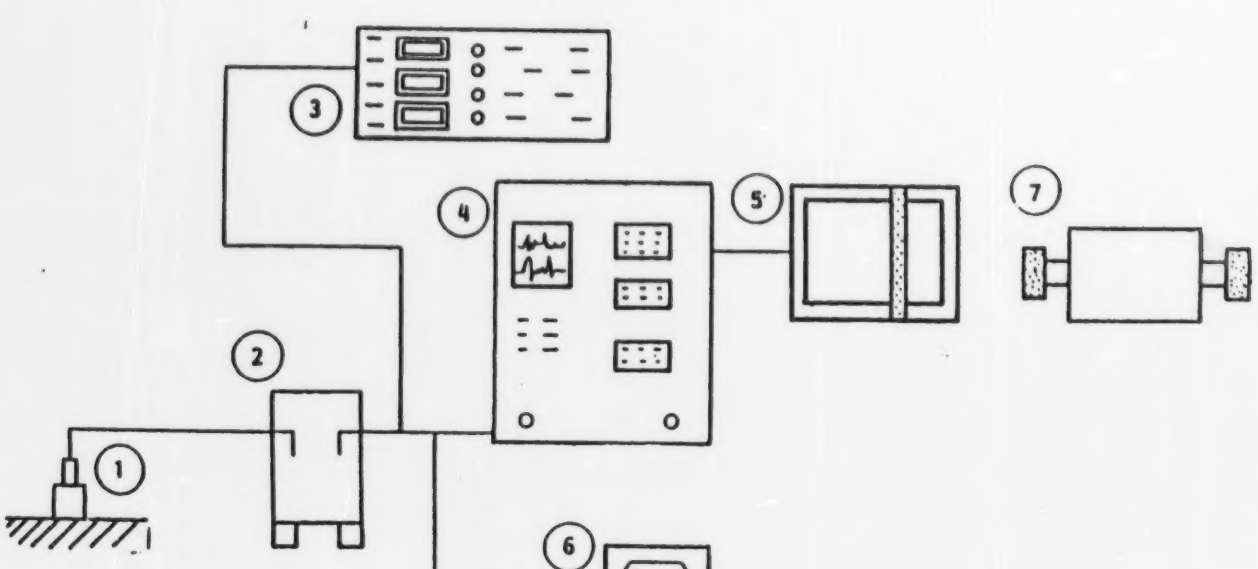


FIGURE 2

DARLINGTON NGS 'A' LOW PRESSURE SERVICE WATER PUMP CHARACTERISTIC CURVE



1) Accelerometer - Bruel & Kjaer
Model 4368

2) Charge Amplifier - Bruel & Kjaer
Type 2635

3) Digitial Vector Filter - Bently Nevada
Model DVF2

4) FFT Analyzer - Ono Sokki Dual Channel
CF 940

5) Plotter - Hewlett-Packard
7470 A

6) Oscilloscope - Textronix
Model 5110 MOD 709V

7) Instrumented Tip Hammer - PCB Piezotronics Inc.
Model 086B50

FIGURE 3

INSTRUMENTATION SETUP

2-7210-P1-A (SOFT) VEL TOP OF MOTOR (mm/s) 3
200Hz A: AC/ 50V B: AC/0.1V S.SUM 16/16 DUAL 1k

PWR SPECTRUM	ChB		
1	12.00Hz	.249E+1	EU
2	120.00	.832E+0	
3	71.50	.718E+0	
4	24.00	.562E+0	
5	16.00	.447E+0	
6	132.00	.342E+0	
7	5.00	.148E+0	
8	47.50	.944E-1	
9	20.00	.644E-1	
10	83.50	.691E-1	

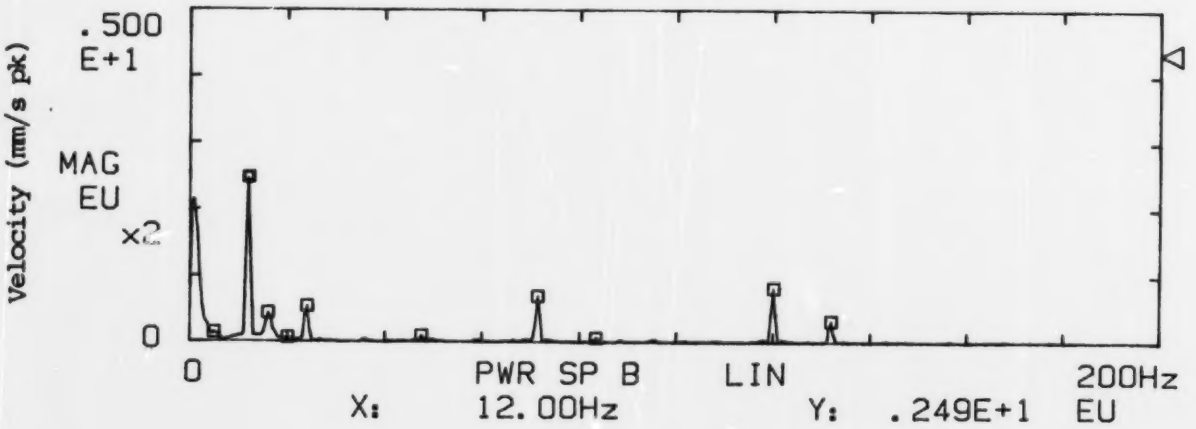


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FIGURE 4
UNIT #2 LPSW PUMPSET #1 - TOP OF MOTOR CASING VELOCITY E-W (SOFT) DIRECTION
(2400 L/S, 420 KPa)

2-7210-P1-ANS (HARD) VEL TOP OF MOTOR (mm/s)
200Hz A: AC/ 50V B: AC/0.1V S. SUM 16/16 DUAL 1k

PWR SPECTRUM	ChB		
1	12.00Hz	.207E+1	EU
2	120.00	.746E+0	
3	15.50	.647E+0	
4	71.50	.577E+0	
5	24.00	.227E+0	
6	47.50	.120E+0	
7	132.00	.108E+0	
8	73.00	.828E-1	
9	3.50	.630E-1	
10	83.50	.640E-1	

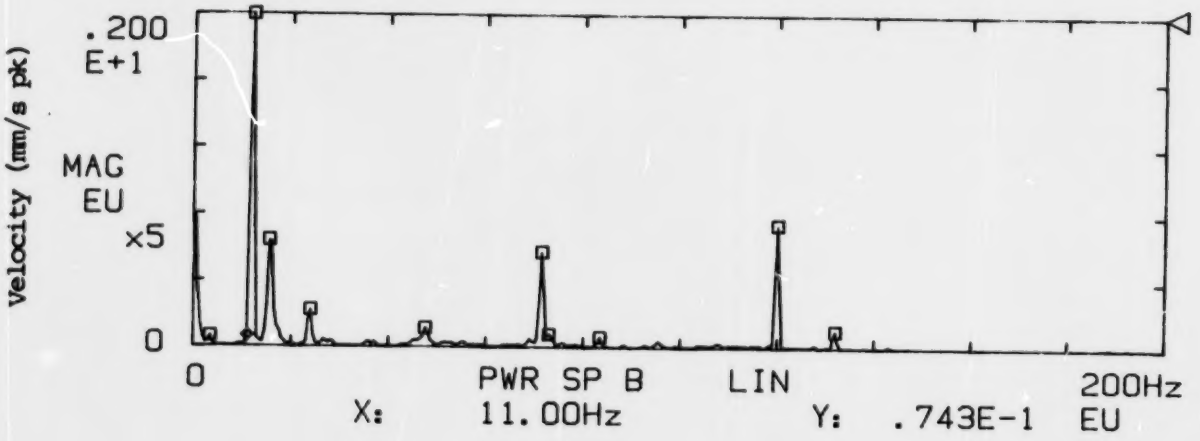

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FIGURE 5
UNIT #2 LPSW PUMPSET #1 - TOP OF MOTOR CASING VELOCITY N-S (HARD) DIRECTION
(2400 L/S, 420 KPa)

2-7210-P1-BEW (SOFT) VEL BOT OF MOTOR (mm/s) 6
200Hz A: AC/ 50V B: AC/50mV S. SUM 16/16 DUAL 1k

PWR SPECTRUM	ChB		
1	12.00Hz	.120E+1	EU
2	120.00	.619E+0	
3	71.50	.364E+0	
4	16.00	.231E+0	
5	24.00	.201E+0	
6	132.00	.193E+0	
7	127.50	.543E-1	
8	60.00	.429E-1	
9	83.50	.440E-1	
10	36.00	.268E-1	

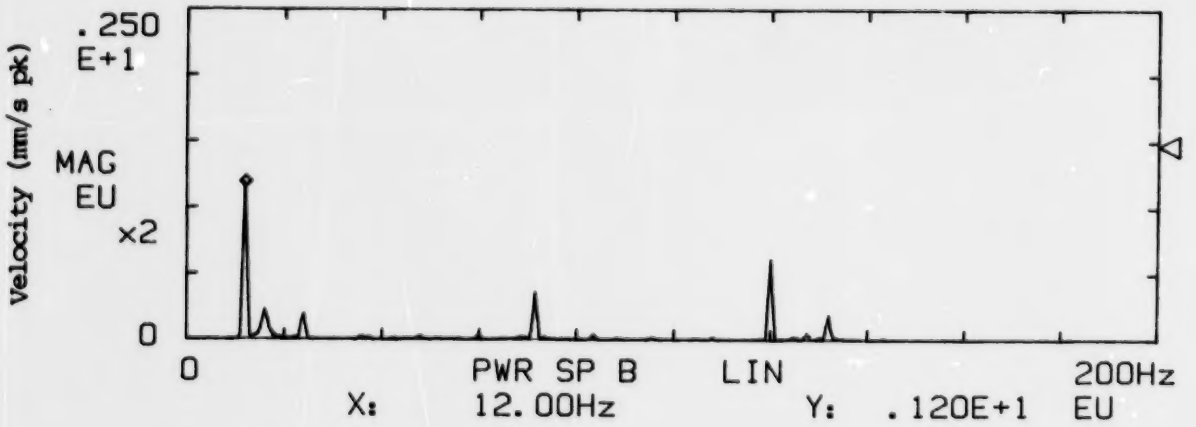

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FIGURE 6
UNIT #2 LPSW PUMPSET #1 - BOTTOM OF MOTOR CASING VELOCITY E-W (SOFT) DIRECTION
(2400 L/S, 420 KPa)

2-7210-P1-BNS (HARD) VEL BOT OF MOTOR (mm/s) 7
200Hz A: AC/ 50V B: AC/50mV S. SUM 16/16 DUAL 1k

PWR SPECTRUM	ChB		
1	12.00Hz	.109E+1	EU
2	120.00	.717E+0	
3	16.00	.292E+0	
4	24.00	.200E+0	
5	71.50	.190E+0	
6	132.00	.153E+0	
7	127.50	.794E-1	
8	83.50	.576E-1	
9	75.50	.398E-1	
10	10.00	.345E-1	

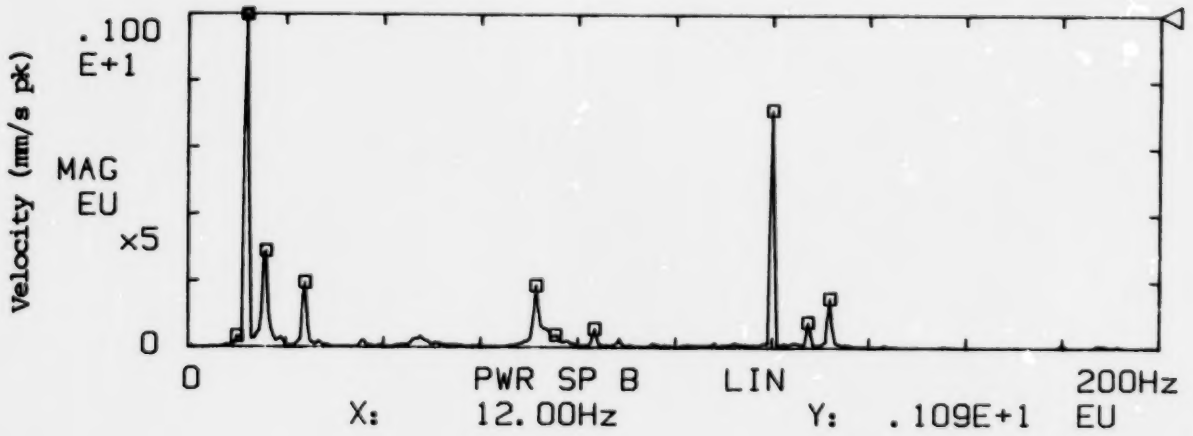

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FIGURE 7
UNIT #2 LPSW PUMPSET #1 - BOTTOM OF MOTOR CASING VELOCITY N-S (HARD) DIRECTION
(2400 L/S, 420 KPa)

2-7210-P1-C (soft) VEL PUMP SEAL FG (mm/s) 9
200Hz A: AC/ 50V B: AC/50mV S. SUM 16/16 DUAL 1k

PWR SPECTRUM	ChB		
1	12.00Hz	.541E+0	EU
2	16.00	.907E-1	
3	71.50	.773E+0	
4	120.00	.197E+0	
5	132.00	.338E+0	
6	143.00	.838E-1	
7			
8			
9			
10			

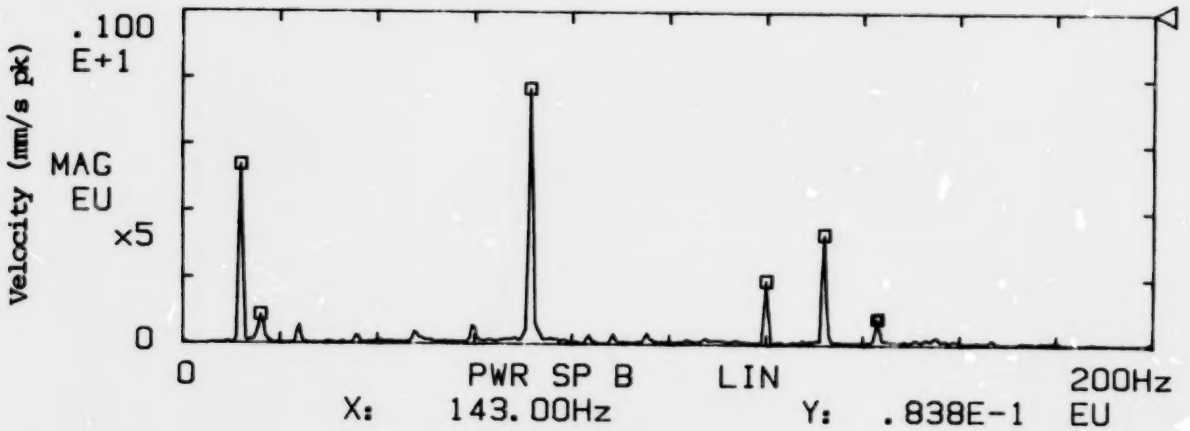

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FIGURE 8
UNIT #2 LPSW PUMPSET #1 - PUMP SEAL FLANGE VELOCITY E-W (SOFT) DIRECTION
(2400 L/S, 420 KPa)

2-7210-P1-C (HARD) VEL PUMP SEAL FG (mm/s) 9
200Hz A: AC/ 50V B: AC/20mV S. SUM 16/16 DUAL 1k

PWR SPECTRUM	ChB		
1	12.00Hz	.264E+0	EU
2	16.00	.258E-1	
3	71.50	.162E+0	
4	120.00	.471E-1	
5	132.00	.468E-1	
6	143.00	.582E-1	
7			
8			
9			
10			

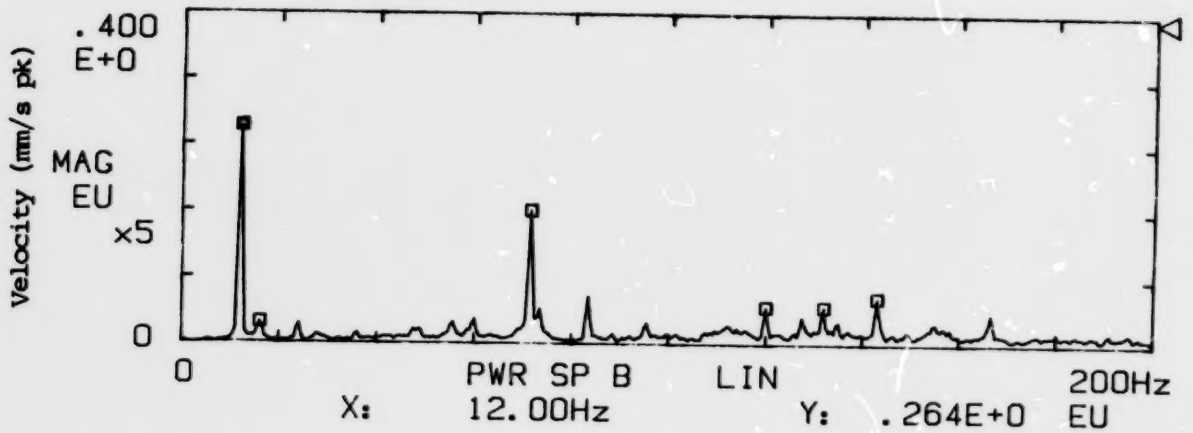

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FIGURE 9
UNIT #2 LPSW PUMPSET #1 - PUMP SEAL FLANGE VELOCITY N-S (HARD) DIRECTION
(2400 L/S, 420 KPa)

2-7210-P3-AEW (SOFT) TOP OF MOTOR VEL (mm/s)
50kHz A: AC/ 50V B: AC/ 10V INST 0/32 DUAL 1k

PWR SPECTRUM	ChB	
1	12.00Hz	.111E+1 EU
2	15.50	.389E+0
3	24.00	.632E+0
4	71.50	.704E+0
5	120.00	.487E+0
6		
7		
8		
9		
10		

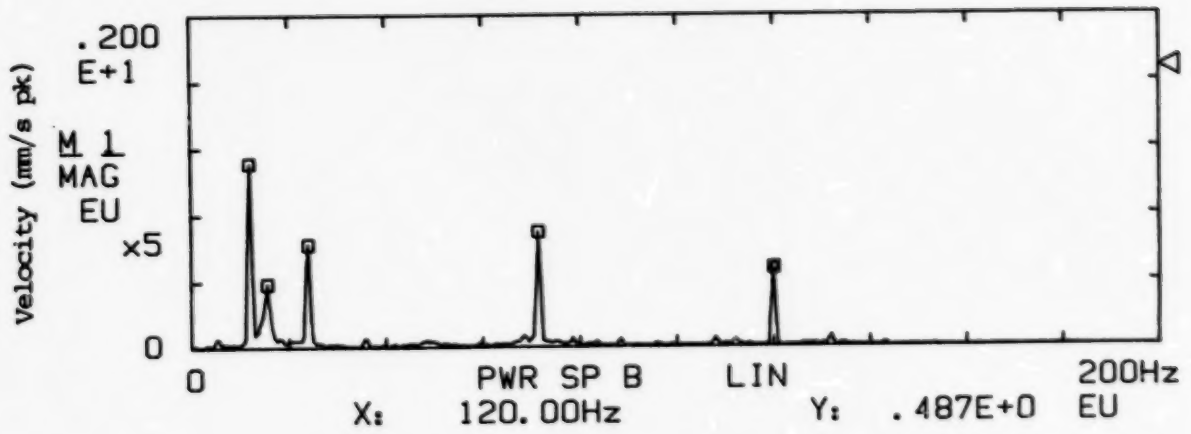

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FIGURE 10
UNIT #2 LPSW PUMPSET #3 - TOP OF MOTOR CASING VELOCITY E-W (SOFT) DIRECTION
(2400 L/S, 420 KPa)

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2-7210-P3-ANS (HARD) TOP OF MOTOR VEL (mm/s)
50kHz A: AC/ 50V B: AC/ 10V INST 0/32 DUAL 1k

PWR SPECTRUM	ChB		
1	12.00Hz	.723E+0	EU
2	120.00	.677E+0	
3	24.00	.531E+0	
4	71.50	.499E+0	
5	15.50	.376E+0	
6	108.00	.830E-1	
7	83.50	.726E-1	
8	47.50	.709E-1	
9	88.50	.539E-1	
10	58.00	.516E-1	

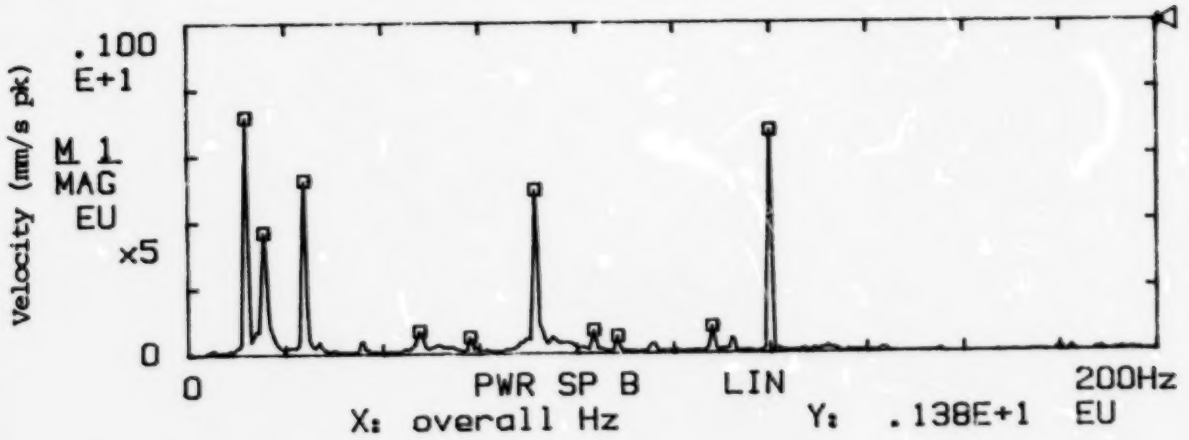

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FIGURE 11
UNIT #2 LPSW PUMPSET #3 - TOP OF MOTOR CASING VELOCITY N-S (HARD) DIRECTION
(2400 L/S, 420 KPa)

2-7210-P3-BEW (SOFT) BOT OF MOTOR VEL (mm/s)
50kHz A: AC/ 50V B: AC/ 10V INST 0/32 DUAL 1k

PWR SPECTRUM	ChB		
1	12.00Hz	.632E+0	EU
2	15.50	.348E+0	
3	24.00	.307E+0	
4	71.50	.496E+0	
5	120.00	.960E+0	
6			
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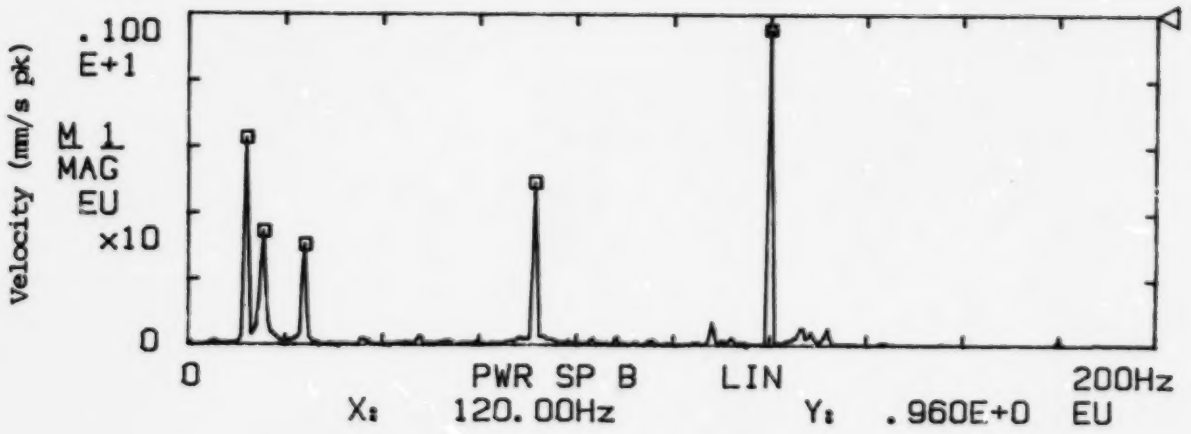

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FIGURE 12
UNIT #2 LPSW PUMPSET #3 - BOTTOM OF MOTOR CASING VELOCITY E-W (SOFT) DIRECTION
(2400 L/S, 420 KPa)

2-7210-P3-BNS (HARD) BOT OF MOTOR VEL (mm/s)
50kHz A: AC/ 50V B: AC/ 10V INST 0/32 DUAL 1k

PWR SPECTRUM	ChB		
1	12.00Hz	.437E+0	EU
2	16.00	.272E+0	
3	24.00	.361E+0	
4	71.50	.393E+0	
5	120.00	.891E+0	
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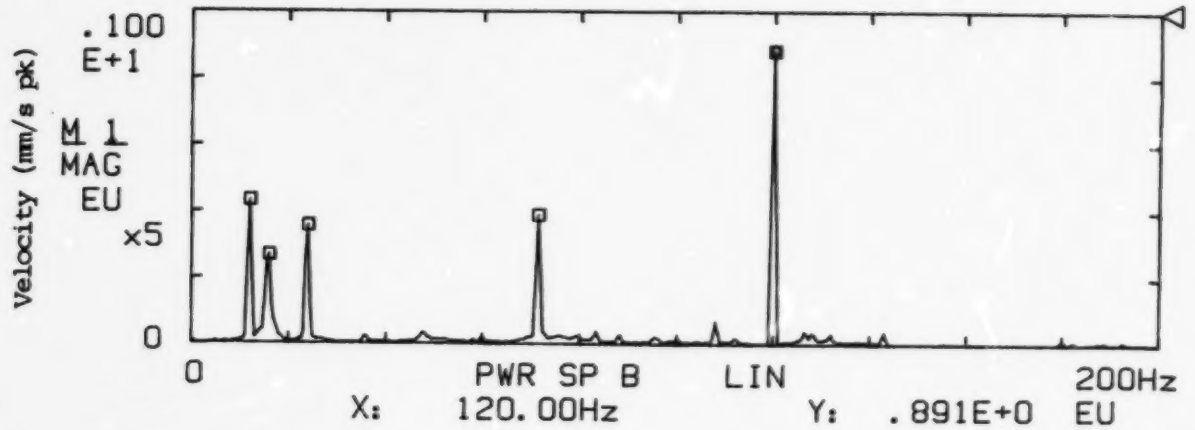

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FIGURE 13
UNIT #2 LPSW PUMPSET #3 - BOTTOM OF MOTOR CASING VELOCITY N-S (HARD) DIRECTION
(2400 L/S, 420 KPa)

2-7210-P3-CEW (SOFT) PUMP SEAL FG VEL (mm/s)
50kHz A: AC/ 50V B: AC/ 10V INST 0/32 DUAL 1k

PWR SPECTRUM	ChB	
1	12.00Hz	.283E+0 EU
2	15.50	.970E-1
3	24.00	.558E-1
4	71.50	.706E+0
5	120.00	.343E+0
6		
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9		
10		

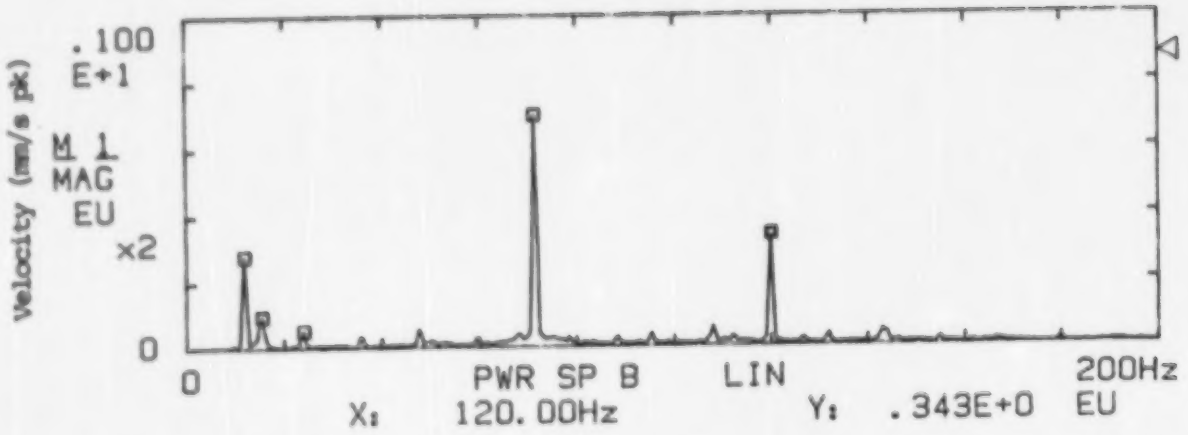

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FIGURE 14
UNIT #2 LPSW PUMPSET #3 - PUMP SEAL FLANGE VELOCITY E-W (SOFT) DIRECTION
(2400 L/S, 420 KPa)

2-7210-P3-CNS (HARD) PUMP SEAL FG VEL (mm/s)
50kHz A: AC/ 50V B: AC/ 10V INST 0/32 DUAL 1k

PWR SPECTRUM	ChB		
1	12.00Hz	.126E+0	EU
2	120.00	.102E+0	
3	71.50	.793E-1	
4	143.00	.775E-1	
5	83.50	.603E-1	
6	24.00	.326E-1	
7	155.00	.316E-1	
8	15.50	.290E-1	
9	127.00	.271E-1	
10	73.50	.264E-1	

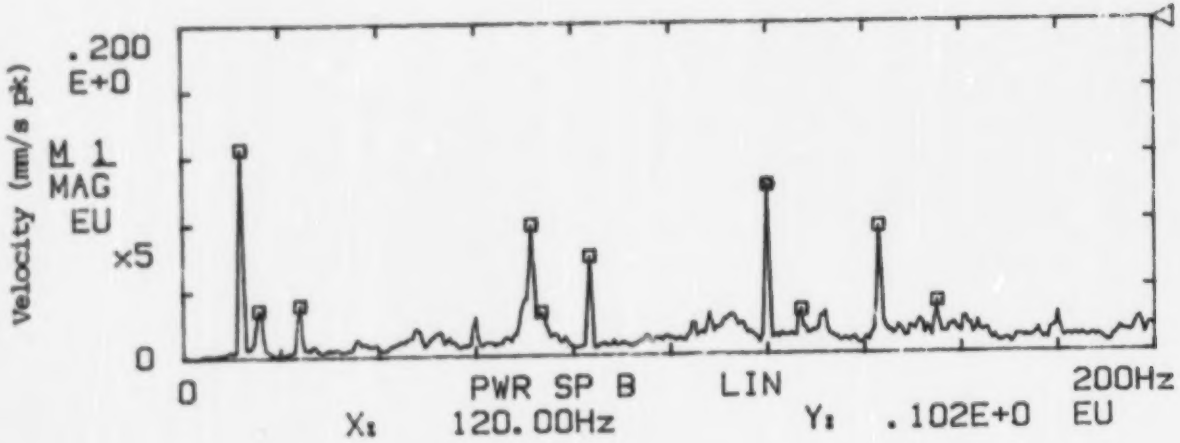

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FIGURE 15
UNIT #2 LPSW PUMPSET #3 - PUMP SEAL FLANGE VELOCITY N-S (HARD) DIRECTION
(2400 L/S, 420 KPa)

2-7210-P3-AEW (SOFT) TOP OF MOTOR VEL (mm/s) 450KPA
50kHz A: AC/ 50V B: AC/ 10V INST 0/32 DUAL 1k

PWR SPECTRUM	ChB		
1	12.00Hz	.120E+1	EU
2	15.50	.113E+1	
3	24.00	.857E+0	
4	71.50	.624E+0	
5	120.00	.493E+0	
6			
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9			
10			

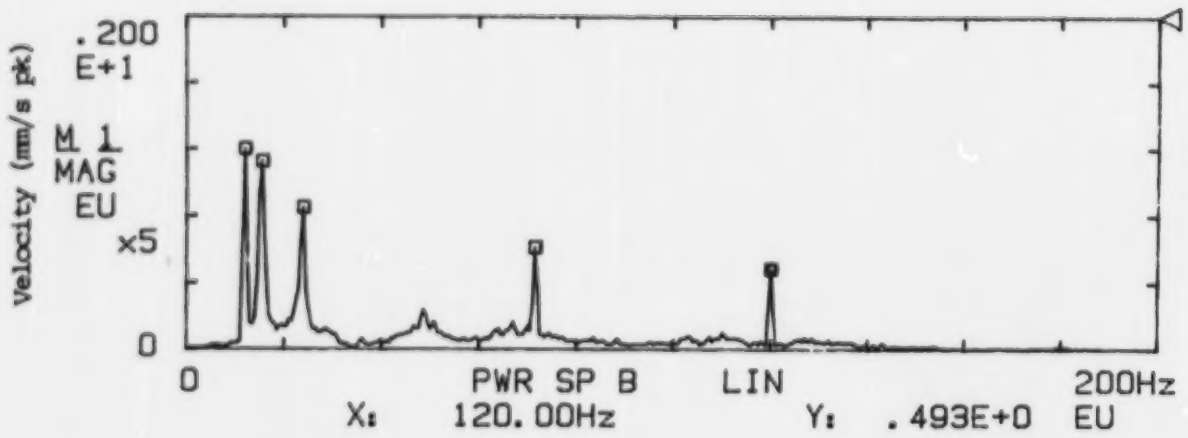

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FIGURE 16
UNIT #2 LPSW PUMPSET #3 - TOP OF MOTOR CASING VELOCITY E-W (SOFT) DIRECTION
(2250 L/S, 450 KPa)

2-7210-P3-ANS (HARD) TOP OF MOTOR VEL (mm/s) 450KPA
50kHz A: AC/ 50V B: AC/ 10V INST 0/32 DUAL 1k

PWR SPECTRUM	ChB		
1	12.00Hz	.780E+0	EU
2	15.50	.105E+1	
3	24.00	.621E+0	
4	71.50	.894E+0	
5	120.00	.538E+0	
6			
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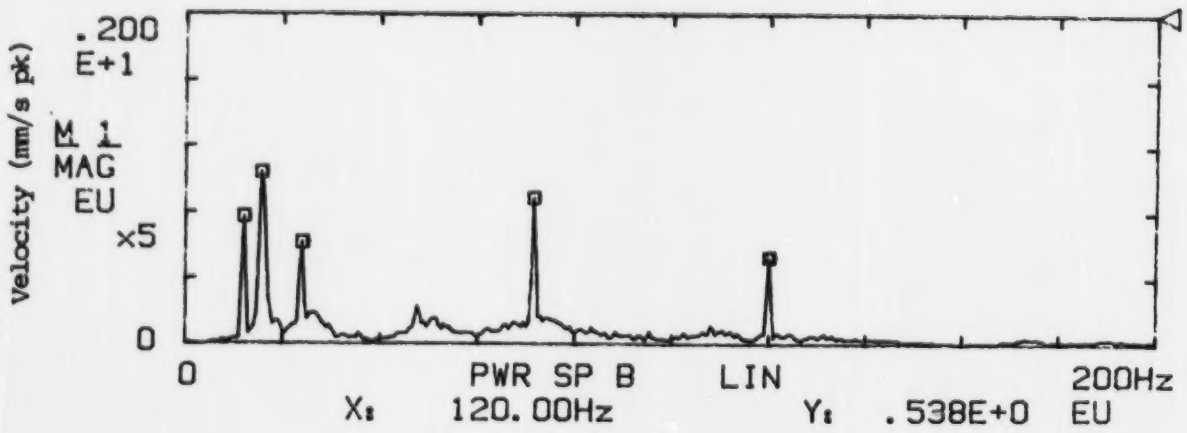

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FIGURE 17
UNIT #2 LPSW PUMPSET #3 - TOP OF MOTOR CASING VELOCITY N-S (HARD) DIRECTION
(2250 L/S, 450 KPa)

2-7210-P3-AEW AXIAL TOP OF MOTOR VEL (mm/s) 450KPA
50kHz A: AC/ 50V B: AC/ 10V INST 0/32 DUAL 1k

PWR SPECTRUM	ChB	
1	12.00Hz	.113E+0 EU
2	15.00	.126E+0
3	24.00	.121E+0
4	71.50	.614E+0
5	120.00	.314E+0
6		
7		
8		
9		
10		

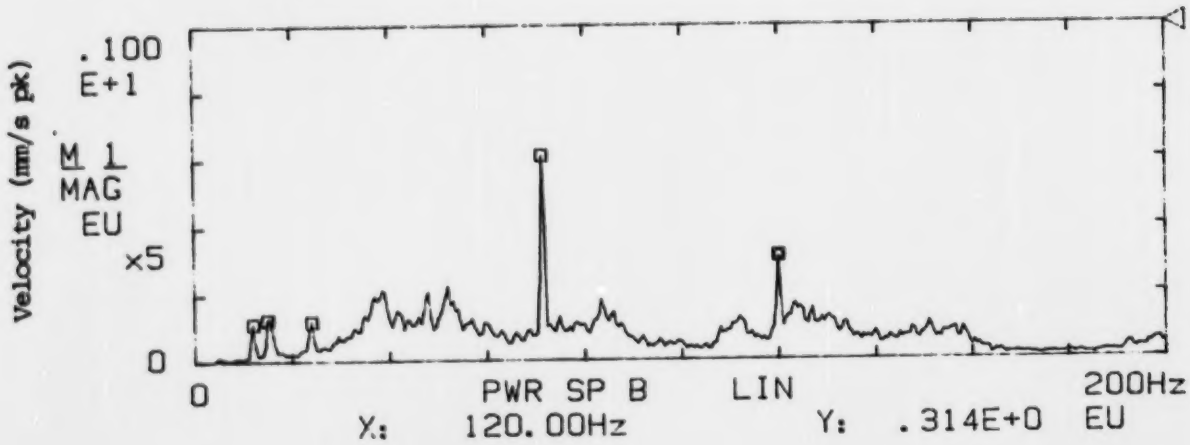

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FIGURE 18
UNIT #2 LPSW PUMPSET #3 - TOP OF MOTOR CASING VELOCITY AXIAL DIRECTION
(2250 L/S, 450 KPa)

2-7210-P3-BEW (SOFT) BOT OF MOTOR VEL (mm/s) 450KPA
50kHz A: AC/ 50V B: AC/ 10V INST 0/32 DUAL 1k

PWR SPECTRUM	ChB		
1	120.00Hz	.108E+1	EU
2	12.00	.697E+0	
3	24.00	.471E+0	
4	15.50	.388E+0	
5	71.50	.269E+0	
6	126.00	.205E+0	
7	125.00	.189E+0	
8	44.50	.839E-1	
9	66.00	.816E-1	
10	19.50	.741E-1	

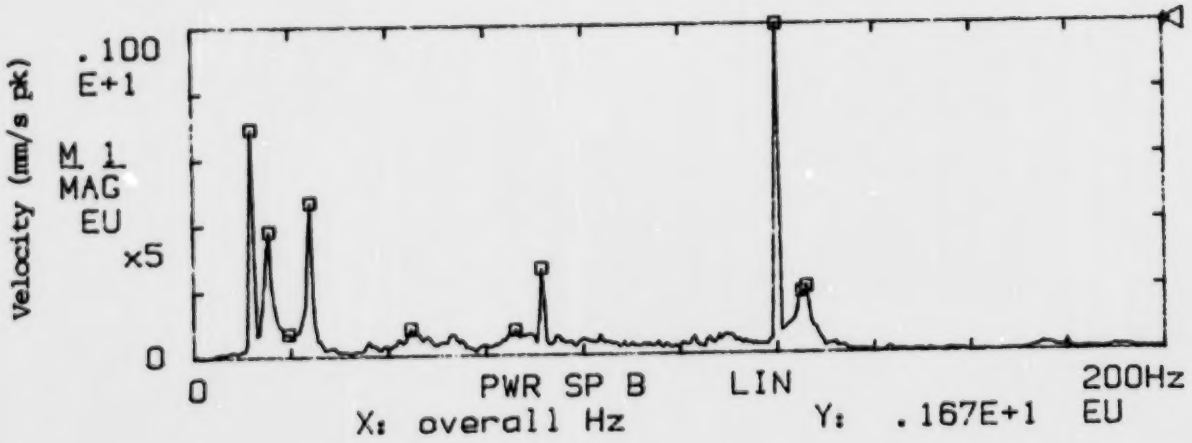

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FIGURE 19
UNIT #2 LPSW PUMPSET #3 - BOTTOM OF MOTOR CASING VELOCITY E-W (SOFT) DIRECTION
(2250 L/S, 450 KPa)

2-7210-P3-BNS (HARD) BOT OF MOTOR VEL (mm/s) 450KPA
50kHz A: AC/ 50V B: AC/ 10V INST C/32 DUAL 1k

PWR SPECTRUM	ChB		
1	120.00Hz	.931E+0	EU
2	71.50	.768E+0	
3	15.50	.757E+0	
4	12.00	.463E+0	
5	24.00	.414E+0	
6	83.50	.150E+0	
7	125.50	.146E+0	
8	76.00	.133E+0	
9	78.50	.134E+0	
10	26.00	.988E-1	

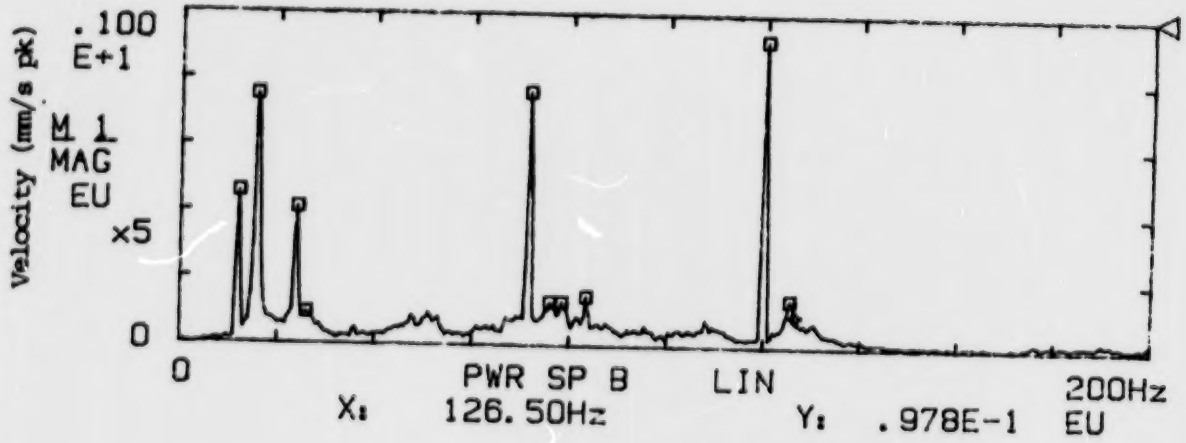

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FIGURE 20
UNIT #2 LPSW PUMPSET #3 - BOTTOM OF MOTOR CASING VELOCITY N-S (HARD) DIRECTION
(2250 L/S, 450 KPa)

2-7210-P3-CEW (SOFT) PUMP SEAL FG VEL (mm/s) 450KPA
50kHz A: AC/ 50V B: AC/ 10V INST 0/32 DUAL 1k

PWR SPECTRUM	ChB		
1	71.50Hz	.716E+0	EU
2	12.00	.314E+0	
3	120.00	.306E+0	
4	15.50	.226E+0	
5	66.50	.143E+0	
6	108.00	.142E+0	
7	50.50	.129E+0	
8	68.00	.120E+0	
9	112.00	.111E+0	
10	48.00	.101E+0	

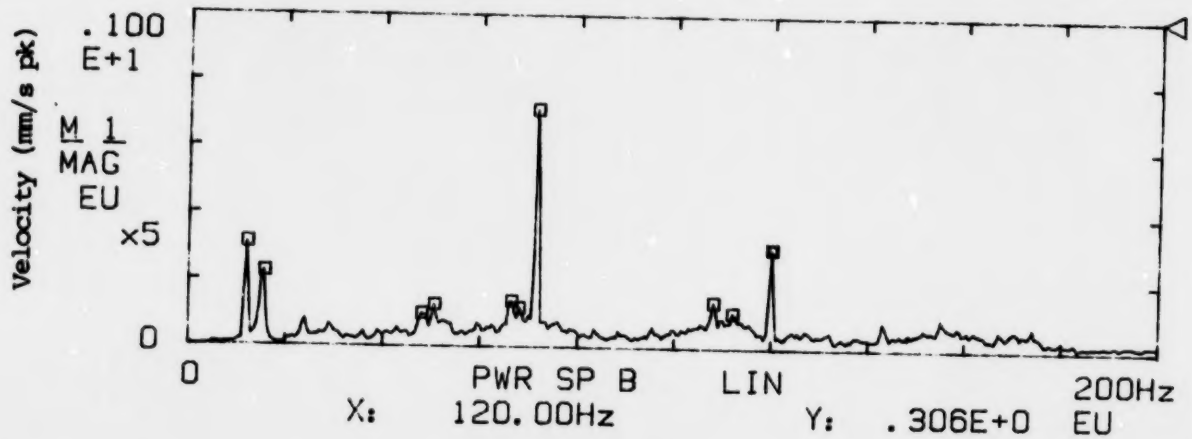

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FIGURE 21
UNIT #2 LPSW PUMPSET #3 - PUMP SEAL FLANGE VELOCITY E-W (SOFT) DIRECTION
(2250 L/S, 450 KPa)

2-7210-P3-CNS (HARD) PUMP SEAL FG VEL (mm/s) 450KPA
50kHz A: AC/ 50V B: AC/ 10V INST 0/32 DUAL 1k

PWR SPECTRUM	ChB		
1	12.00Hz	.125E+0	EU
2	15.50	.831E-1	
3	71.50	.139E+0	
4	103.50	.173E+0	
5	111.50	.285E+0	
6			
7			
8			
9			
10			

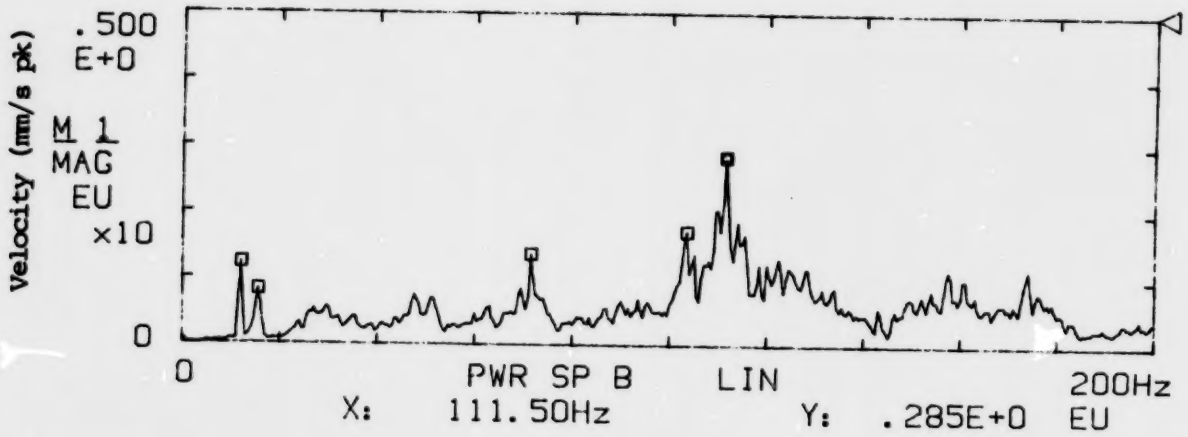

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FIGURE 22
UNIT #2 LPSW PUMPSET #3 - PUMP SEAL FLANGE VELOCITY N-S (HARD) DIRECTION
(2250 L/S, 450 KPa)

2-7210-P3-AEW (SOFT) TOP OF MOTOR IMPACT SPECTRUM
200Hz A: AC/ 2V B: AC/ 2V S. SUM 8/8 DUAL 1k

	XFER FUNC	MAG - PH	
1	15.50Hz	-30.49dBEU/EU	-58.8 deg
2	53.00	-47.17	-113.6
3	71.50	-28.28	-36.9
4			
5			
6			
7			
8			
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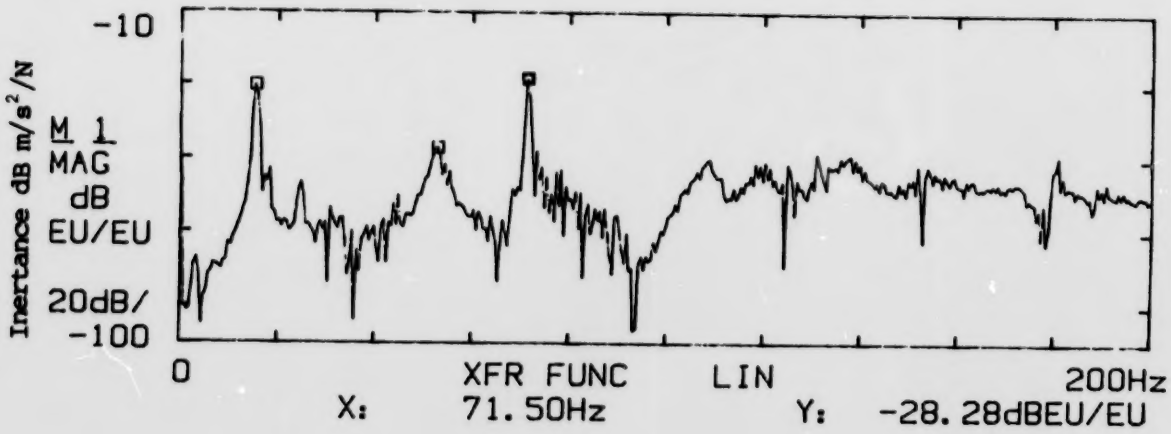

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FIGURE 23
UNIT #2 LPSW PUMPSET #3 - TOP OF MOTOR INERTANCE TRANSFER FUNCTION
E-W (SOFT) DIRECTION

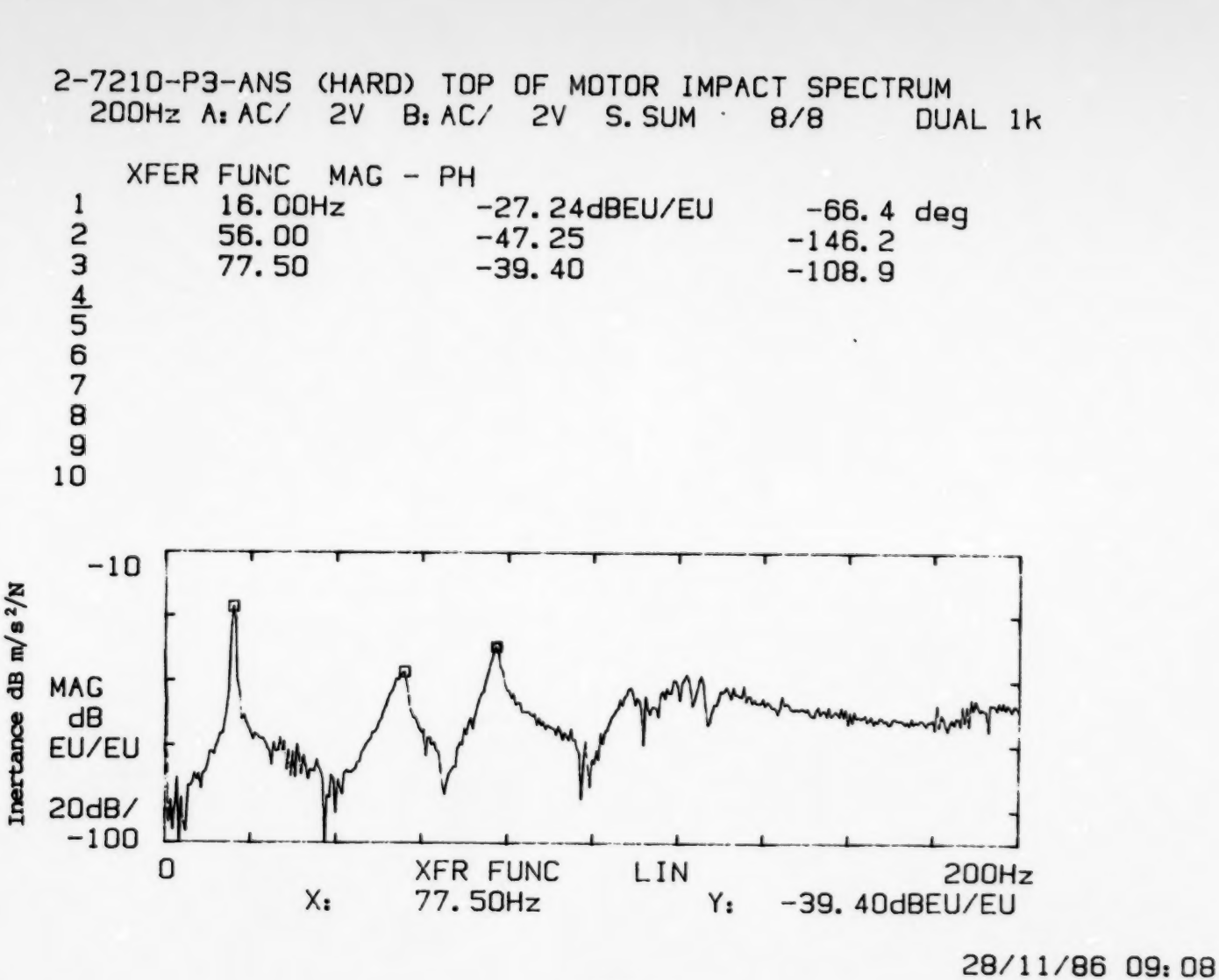

FIGURE 24
UNIT #2 LPSW PUMPSET #3 - TOP OF MOTOR INERTANCE TRANSFER FUNCTION
N-S (HARD) DIRECTION

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